

Search for a Higgs Boson produced in association with W or Z bosons, and decaying into bottom quarks at CMS

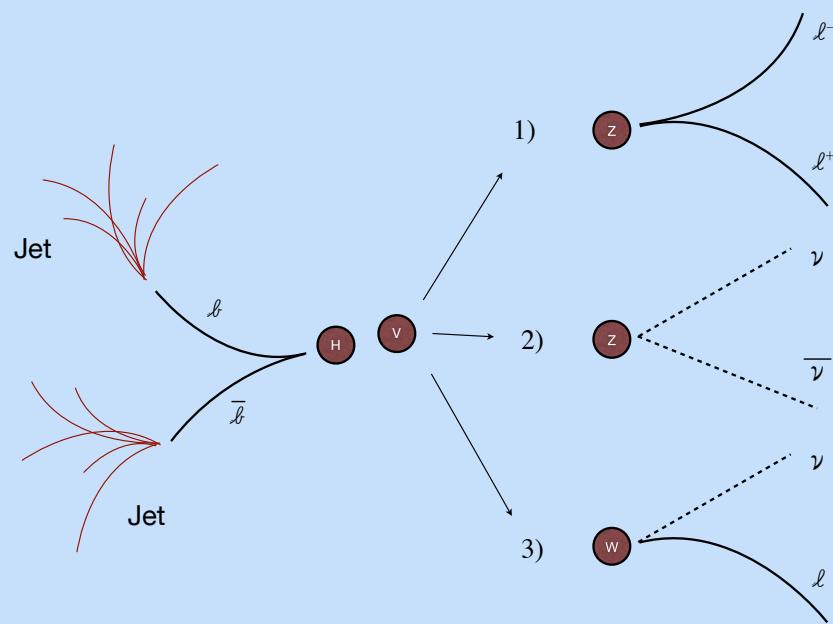


Higgs Hunting
July 26th 2013, Orsay (FR)
Philipp Eller, on behalf of CMS

ETH zürich

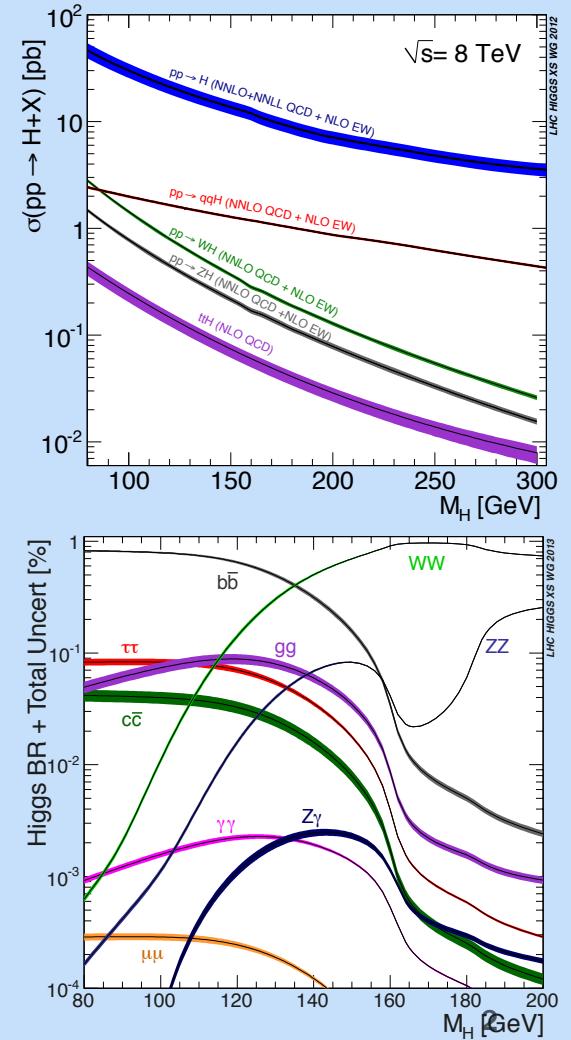
MOTIVATION

- Associated production with Z/W Boson
 - to reduce enormous background
- Higgs decaying into b-quarks
 - highest branching ratio at 125 GeV
 - measurement of fermionic coupling



Philippe Eller - ETH Zurich

26 juillet 2013





ANALYSIS OVERVIEW

2 signals

VH ($H \rightarrow bb$), $M_H = [110...135]$ templates
+[140..150] GeV for 8 TeV only

VZ ($Z \rightarrow bb$)



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6 channels
of the V

$Z \rightarrow ee$

$Z \rightarrow \mu\mu$

$Z \rightarrow \nu\nu$

$W \rightarrow e\nu$

$W \rightarrow \mu\nu$

$W \rightarrow \tau_H \nu$



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2 Analyses

BDT Analysis

- Z or W selection plus loose b-tag requirements
- Different $p_T(V)$ bins in each mode
- BDT trained in each mode to extract both signals
- **MAXIMISING SIGNAL EFFICIENCY**

M_{jj} crosscheck

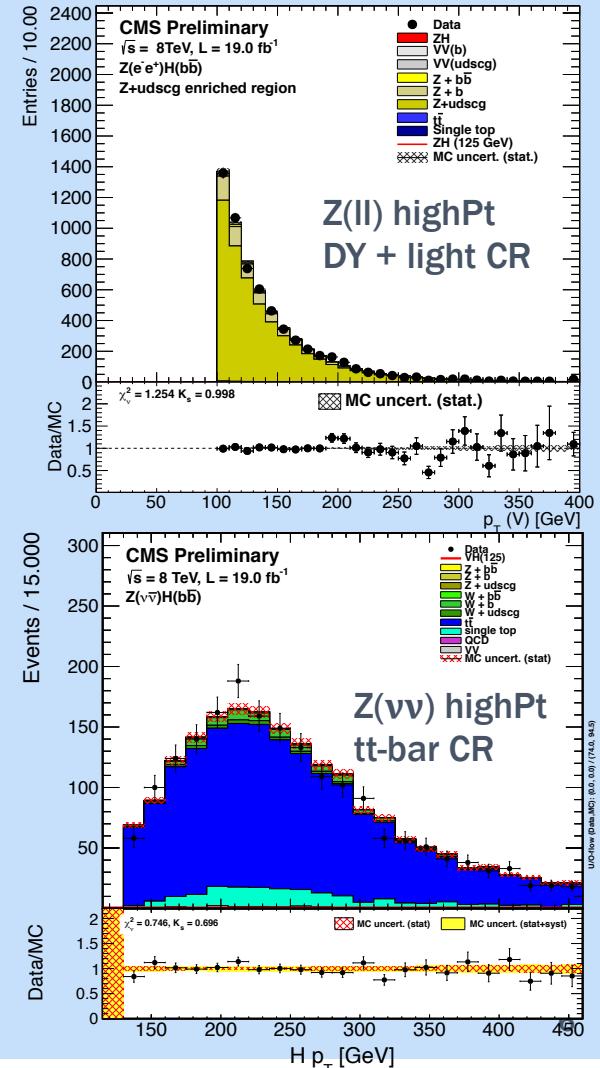
- Strict subset of events used in the BDT analysis
- Tighter selection in b-tagging and other additional selection, different $p_T(V)$ binning
- **OPTIMISING PURITY**

BACKGROUND NORMALIZATION

- Vector + jets and tt-bar
 - normalization from simultaneous fit in mass sidebands

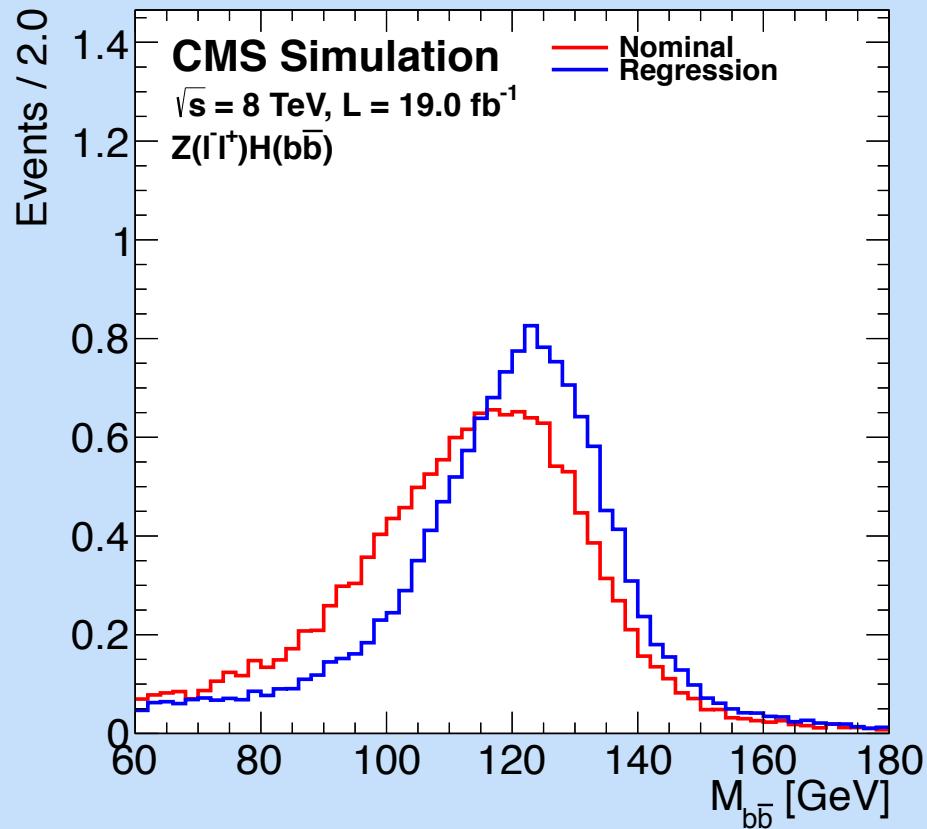
- Diboson, single top (and QCD)
 - normalization from theory

- Good agreement of all variables in the various control regions
 - DY + light jets
 - DY + b jets
 - tt-bar



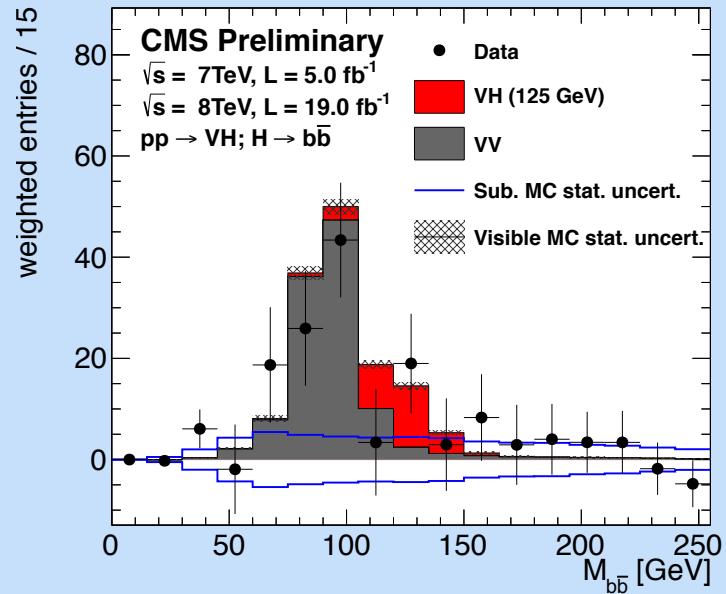
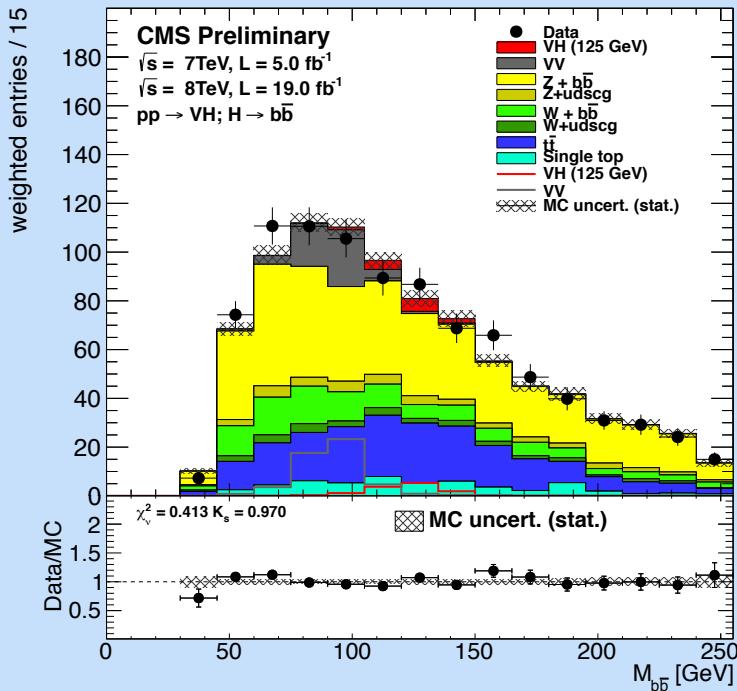
JET ENERGY REGRESSION

- BDT regression to improve the resolution per jet
 - Target gen. jet transverse momentum
 - Jet kinematics, properties, vertex, soft-lepton (MET in ZII) information are used
 - improvement on mass resolution ~15%
 - validated on data
 - p_T balance in DY+jets
 - top mass in single top



DI-JET MASS RESULTS

- Di-Jet invariant mass distribution
 - Weighted each category by $s/(s+b)$ in window 105-150 GeV
 - Plot with all backgrounds subtracted



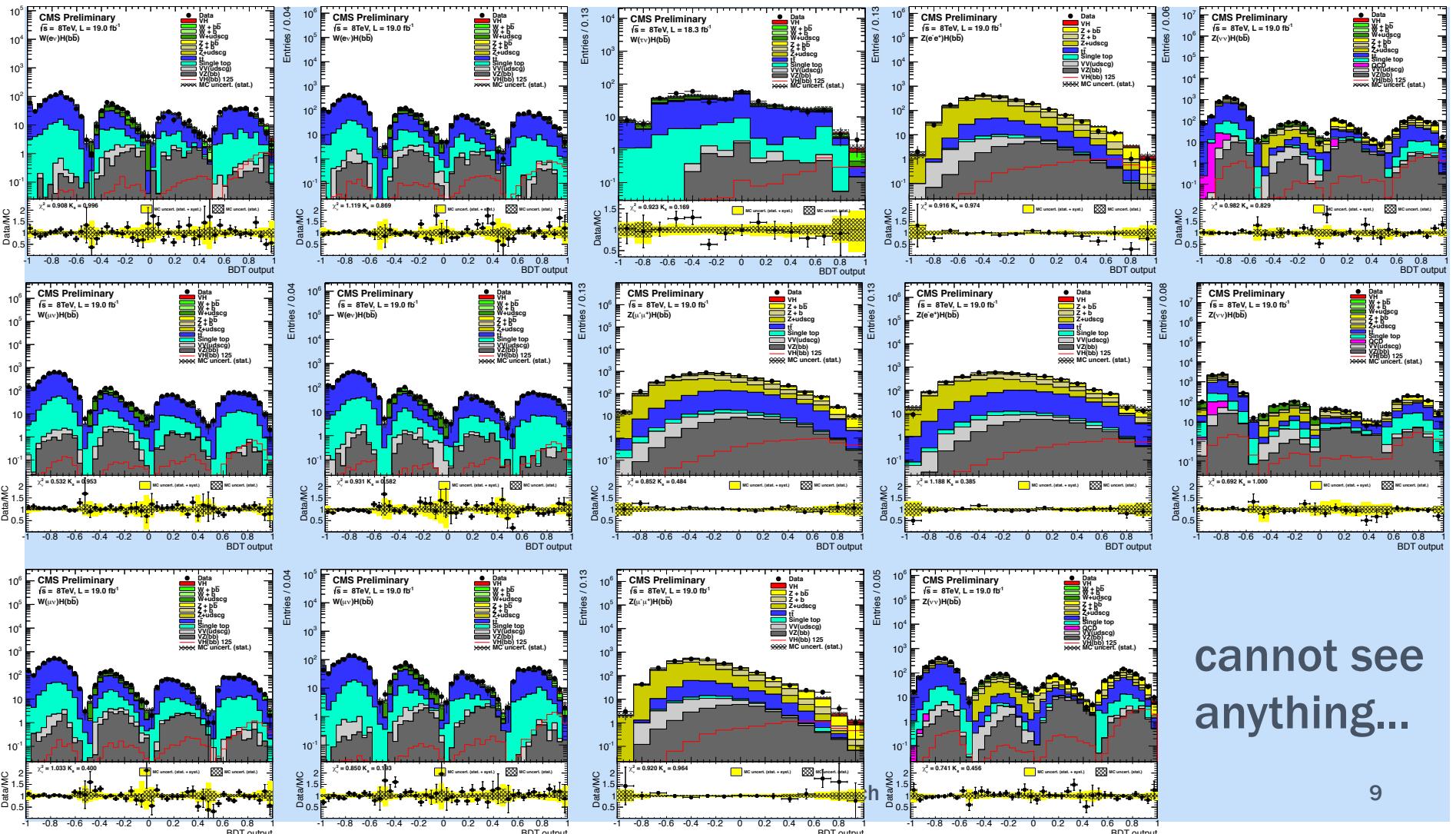
VH:
 $\mu = 0.76^{+0.68}_{-0.66}$ with a sign. of 1.1σ
 Limit: exp. 1.4, obs. $2.0 \times \text{SM}$

VZ:
 $\mu = 0.78^{+0.26}_{-0.23}$ with a sign. of 3.7σ



BDT DISTRIBUTIONS

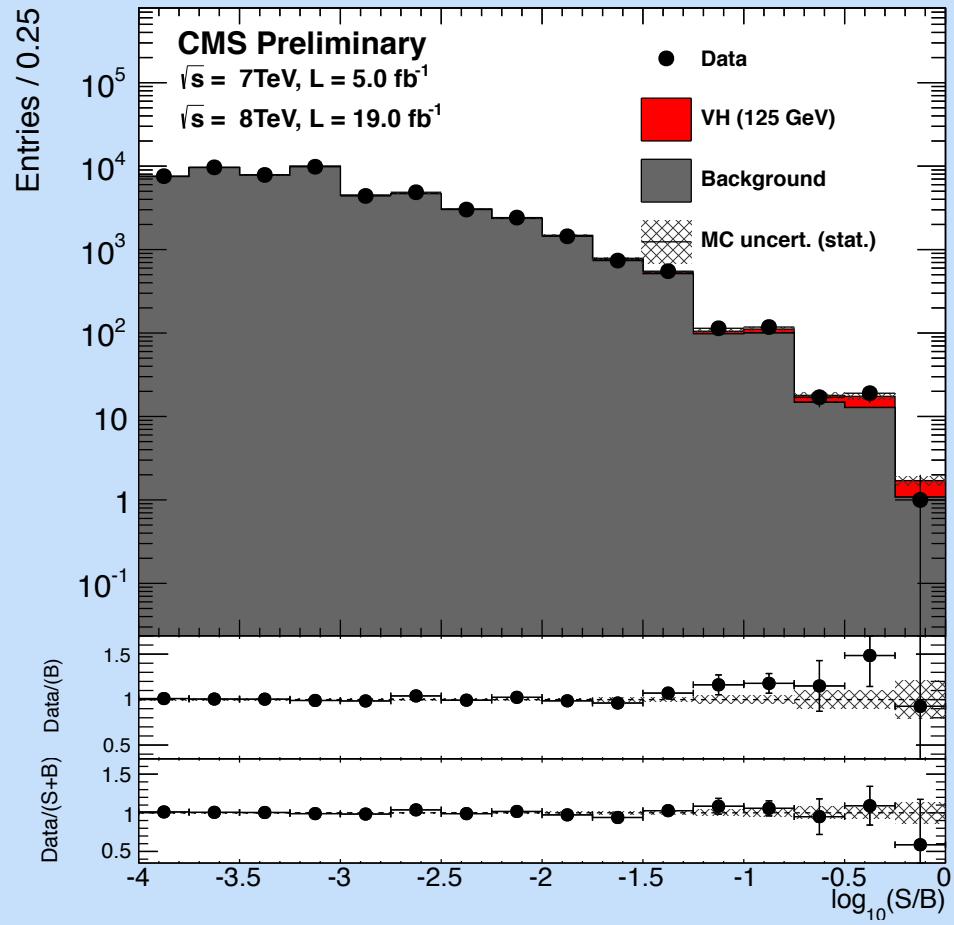
ETH zürich



cannot see
anything...

■ Visualized BDT Output

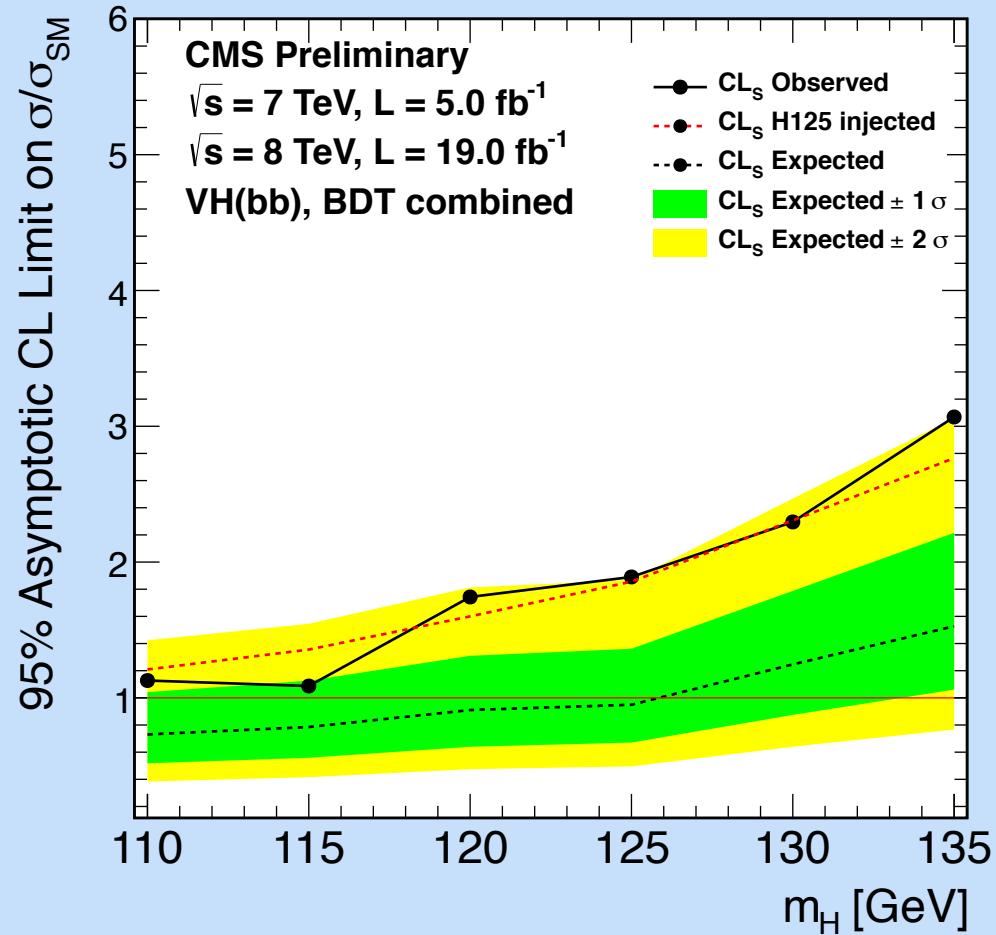
- summary plot containing all BDT bins across all modes, sorted in S/B
- Excess in high discriminant bins of data over background
- Great agreement of Background + Signal Hypothesis



HIGGS BDT RESULTS

■ Exclusion limit

- Limit $1.89 (0.95) \times \text{SM}$ for $M_H = 125 \text{ GeV}$
- Consistent with expectation from a SM Higgs (signal injected limit)



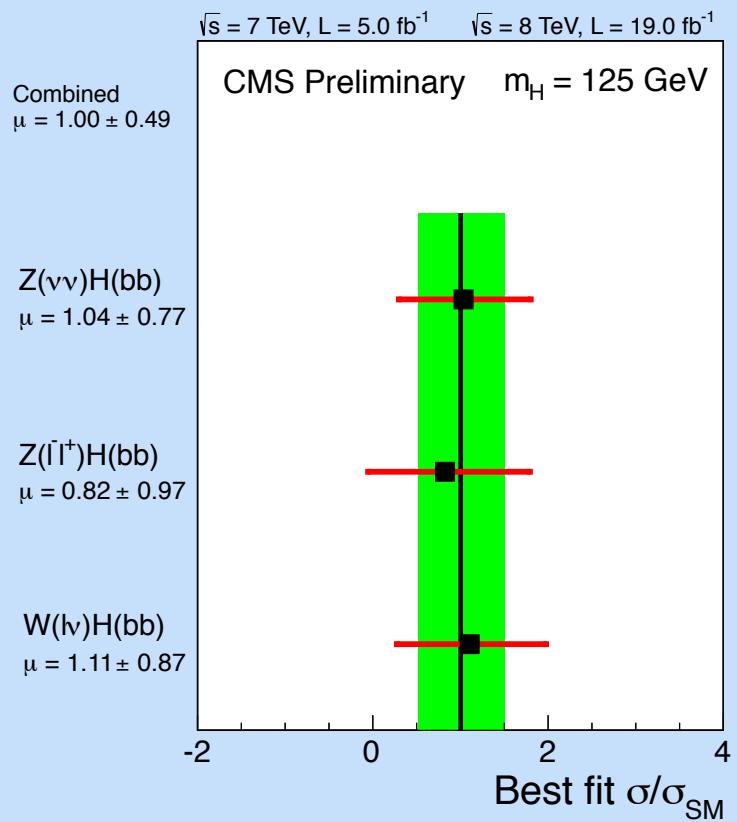
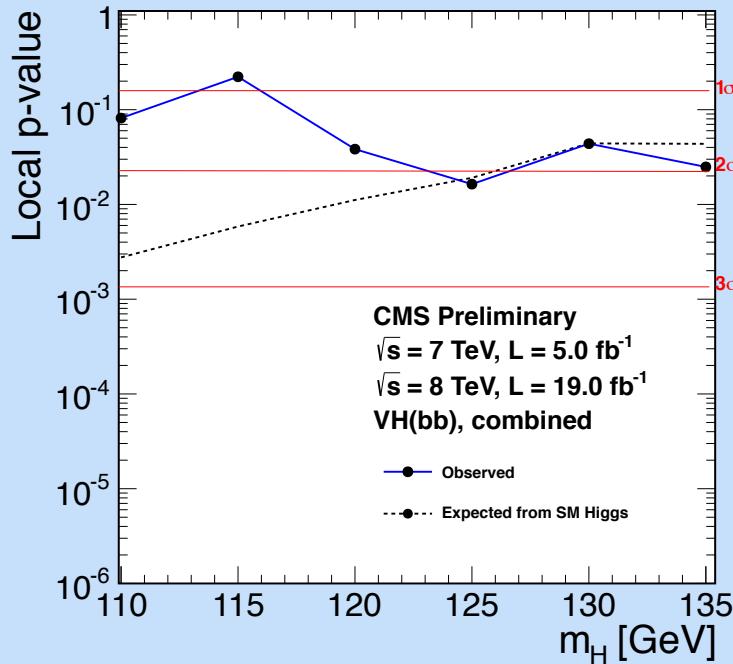
HIGGS BDT RESULTS

■ Local p-value

- Excess at $M_H = 125$ GeV with significance 2.1σ (2.1σ expected)

■ Signal strength

- Best fit $\mu = 1.0^{+0.5}_{-0.5}$, w.r.t NNLO

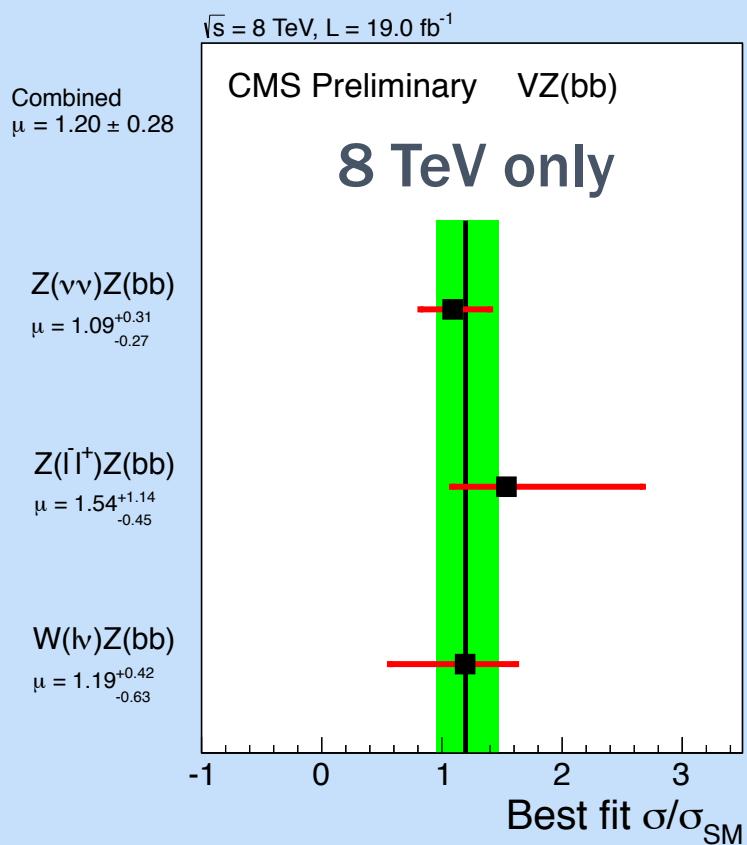


DIBOSON BDT RESULTS

- Signal extracted form BDT fit:

- Measured with 7.5σ
(expected 6.3σ)
- Best fit $\mu = 1.19^{+0.28}_{-0.24}$
- theory value from NLO
- good compatibility between all channels

- Good crosscheck for our Higgs analysis



CONCLUSION

- Diboson (BDT)
 - Measured with 7.5σ (expected 6.3σ)
 - Best fit $\mu = 1.19^{+0.28}_{-0.24}$
- Higgs (BDT, for $M_H = 125$ GeV)
 - Limit 1.89 (0.95) SM
 - Excess with significance 2.1σ
 - Best fit $\mu = 1.0^{+0.5}_{-0.5}$
- Crosscheck
 - results consistent with M_{jj} Analysis





BACKUP

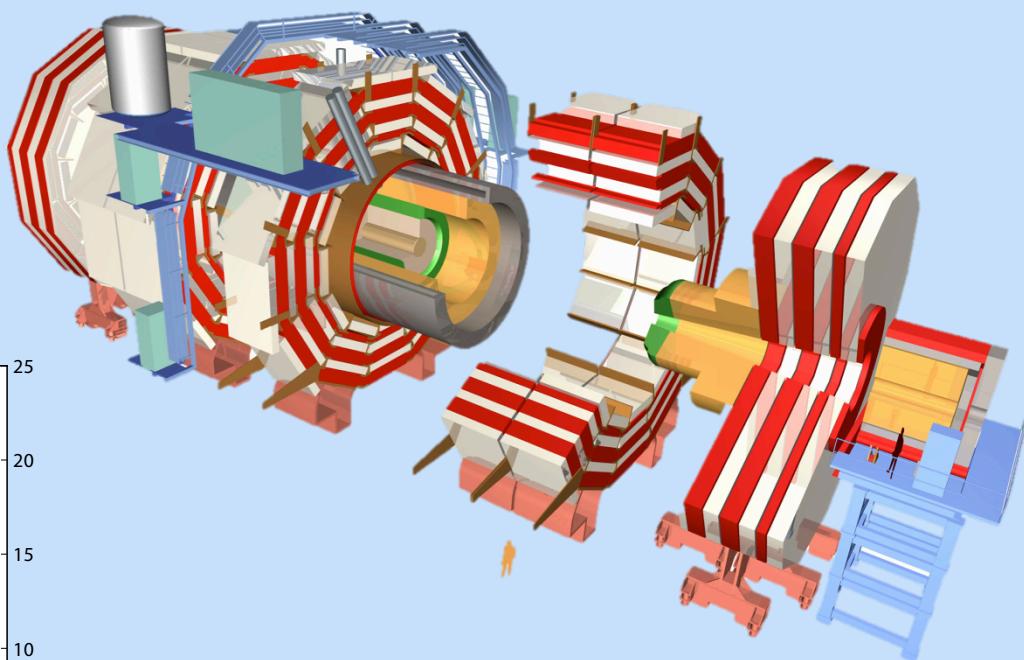
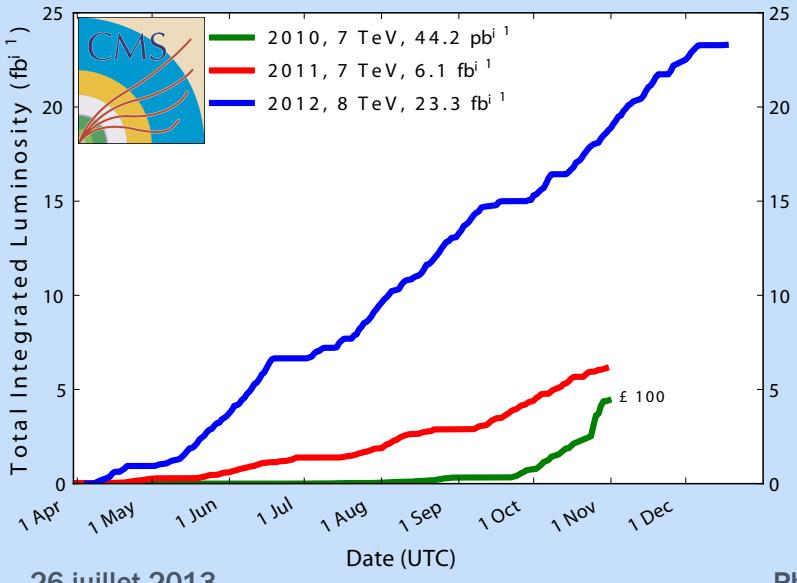
BACKUP

EXPERIMENT & DATASET

Compact Muon Solenoid at the LHC

Datasets (pp-collisions)

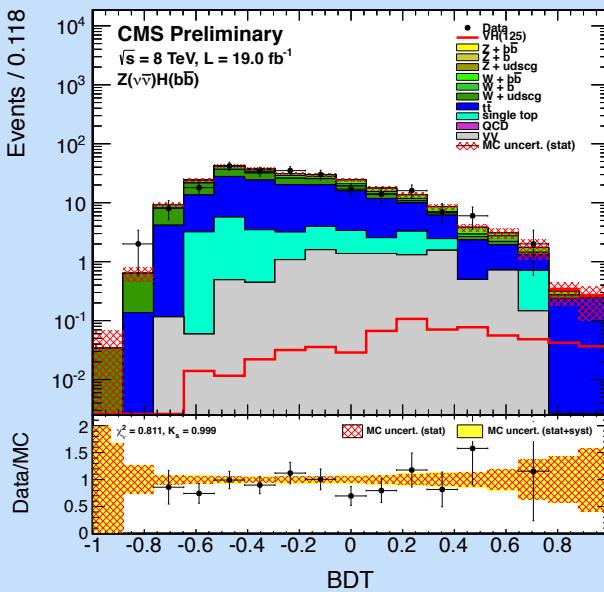
- $L = 5.0 \text{ fb}^{-1}$ of 7 TeV
- $L = 19.0 \text{ fb}^{-1}$ of 8 TeV



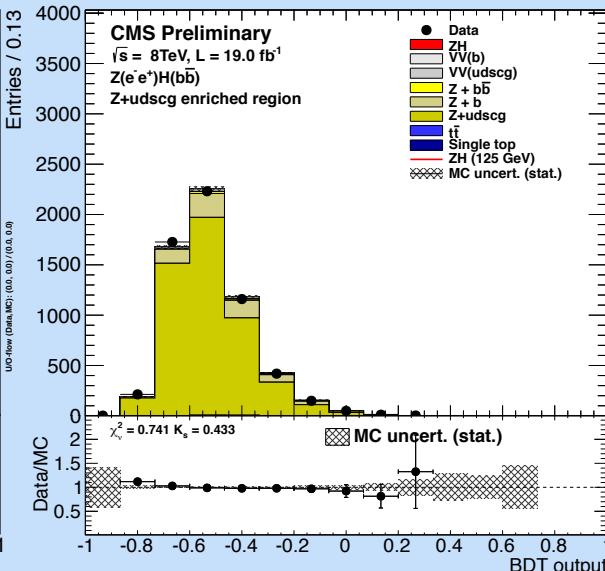
BDT CONTROL REGIONS

■ Example distributions

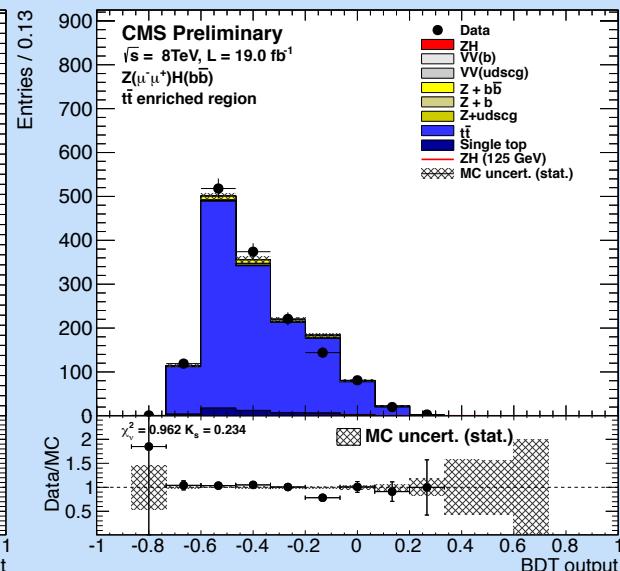
Zvv high p_T W+b-jets



Zee high p_T Z+light-jets

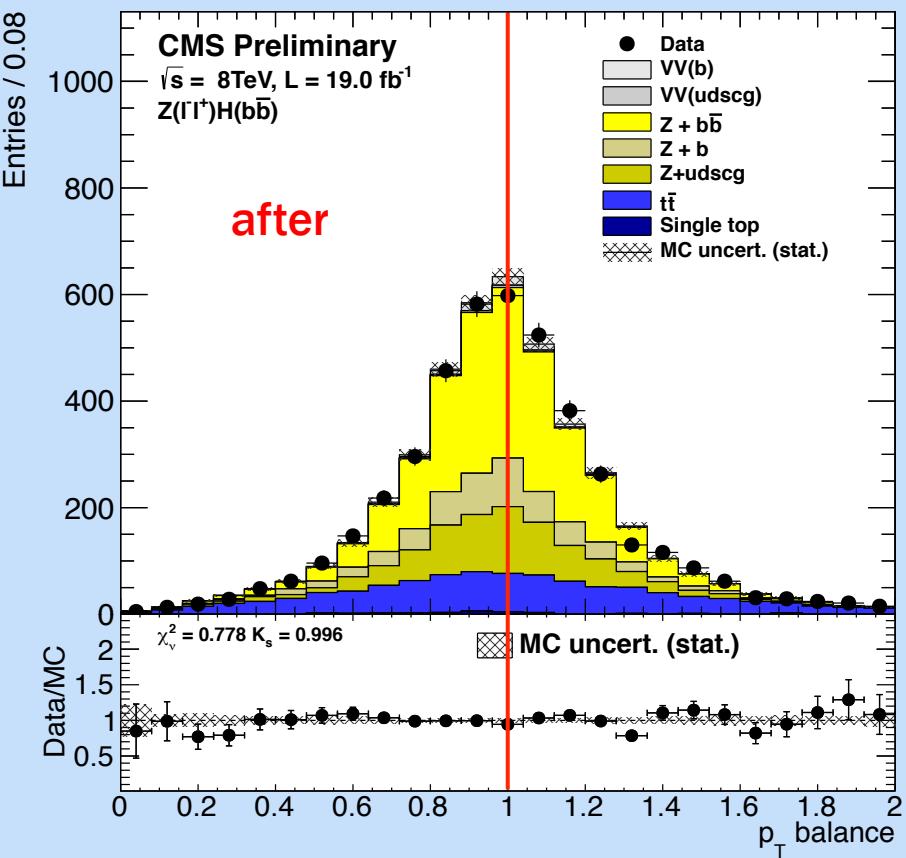
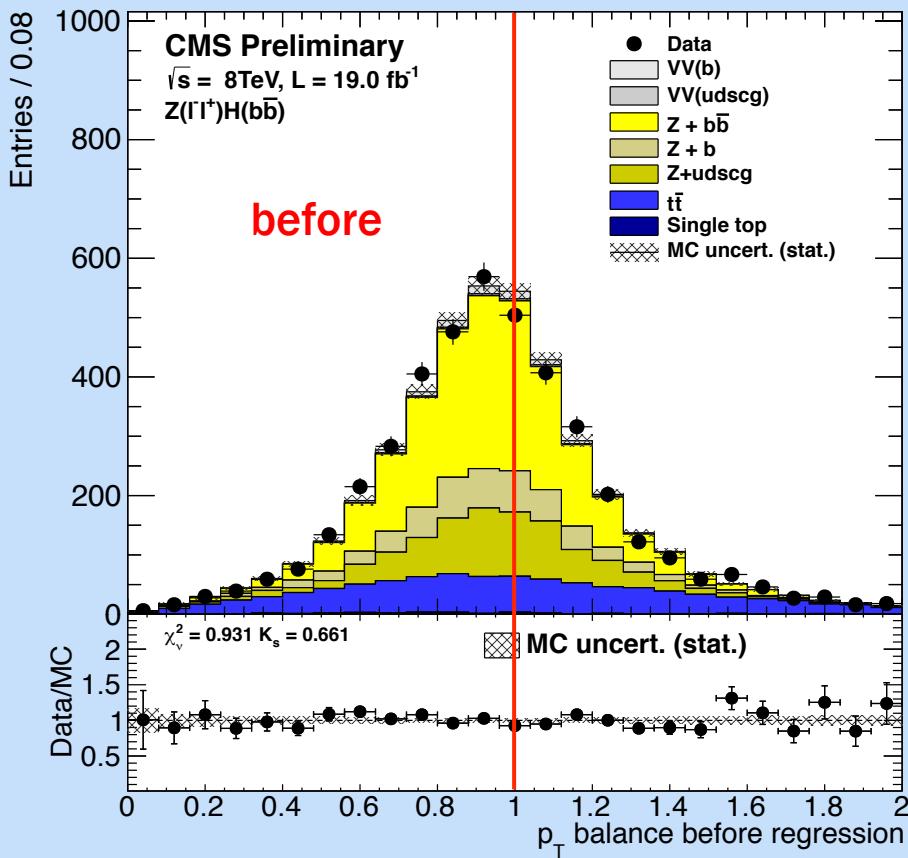


Z $\mu\mu$ high p_T tt-bar



REGRESSION VALIDATION

- Z+jets control region, pT balance of di-lepton vs. di-jets



COUPLINGS

